A 400 kA Pulsed Power Supply for Magnetic Horn at the pbar Separator

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In the planned FAIR pbar separator [1] scheme magnetic horn will be used as a focusing device for highly divergent antiproton beam as it is already in operation at CERN [2] successfully. To achieve the desired operational performance from the horn, it needs to be powered with a very high electrical current pulse of 400 kA peak amplitude with repetition rate up to 0.2 Hz. To limit the power consumption and associated thermal and mechanical stresses on the load-system the pulse duration should be as short as reasonably possible.

As shown in Fig. 1, a high-voltage, energy- storage capacitor bank will be charged by a dc supply to the rated voltage. This stored energy will be released on horn through switches and the discharge path, which includes a set of coaxial cables, adaption box and a radiation-hard stripline. An Adaptive Control Unit will provide communication interface between the accelerator control system and horn system. Possible technical realization of this system has

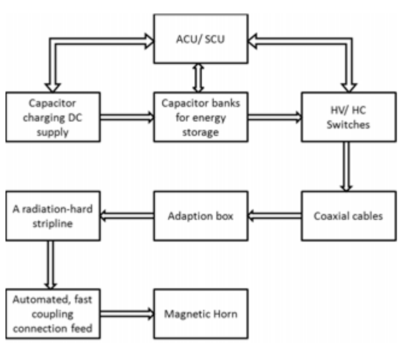

Figure 1: Schematic of the horn pulser system.

some key design aspects. Due to the building construction and radiation protection limitations, physical distance between the power supply and horn is ≈ 65 m. This means additional parasitic impedance. Therefore, resistance and inductance of the discharge path should be as small as reasonably possible. Another key element will be the necessary high voltage switches. A mini-workshop was organized on “Switches for FAIR-Magnetic Horn Pulser System”. For the given the operating parameters, among the possible switch types are ignitrons and solid-state switches. As solid-state switches are not well-known in this power regime presently, the most likely solution seems to be the use of ignitrons. As an attempt for the systematic risk management, meeting has been organized with project control to address the safety concerns due to the mercury contents of the ignitrons. As a risk mitigation strategy, it has been decided to provide a shielding mechanism around the ignitrons in the form of metal containers for effective mercury containment.

Fig.2 shows the basic circuit to produce the required current pulse.

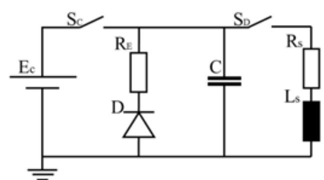

Figure 2: Simplified electrical equivalent circuit of pulser.

A capacitor bank of ≈ 2 mF is charged to a voltage ∼ 15 kV and then discharged through switch S$_D$ in a directly coupled damped circuit with ≈ 1.5 μH inductance and resistivity of ≈ $5m\Omega$. These values represent calculated total effective inductance and resistance, L$_S$ and R$_S$ respectively, of the system. The horn can be regarded as mainly an inductive load with small series resistance. The diode stack D is used to protect the capacitor from excessive reverse voltage during falling period of the horn current. Energy-damping resistor R$_E$ is basically a protective device to dump the significant amount of magnetic energy and thus critically damp the horn current. The whole stored energy is dissipated during each operating cycle. In order to

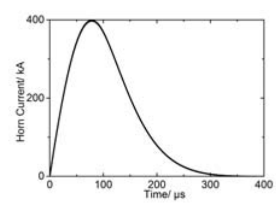

Figure 3: Critically-damped horn current waveform.

study the transient electrical behavior of the pulser circuit, an LTspice simulation [3] has been performed using calculated values of R, L, and C of major system components. A critically-damped horn current waveform, as shown in Fig.3, with 400 kA peak amplitude and duration of 125 μs FWHM has been calculated.

References

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[2] D.Boimond et al.,CERN/PS 94-02 (AR).
[3] LTspice simulation program from www.linear.com

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